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The political ecology of rice intensification in south India: Putting SRI in its places

Marcus Taylor[1] | Suhas Bhasme[2]

[1] Department of Global Development Studies, Queen's University, Kingston, ON, Canada

[2] Ashoka Trust for Research in Ecology and the Environment (ATREE), Bangalore, Karnataka, India

Correspondence
Marcus Taylor, Department of Global Development Studies, School of Environmental Studies, Queen's University, Kingston, ON, Canada.
Email: marcus.taylor@queensu.ca

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Abstract

The system of rice intensification (SRI) has been promoted across Asia as a means to improve rice yields while decreasing water use and external inputs. It is argued to be a generalisable means by which to revalidate smallholder livelihoods and improve food security across the region. Current debates about SRI, however, remain predominantly technical in scope, focusing on field-level outcomes. To more adequately understand the potential of SRI for smallholder farmers, we argue that it is necessary to situate SRI within a political ecology framework that addresses how the adoption and practice of SRI is shaped by uneven access to key assets including labour, water, and extension networks. Fieldwork conducted in Mahabubnagar district in Telangana, south India—where SRI had been widely disadopted despite the achievement of higher yields—is used to illustrate why agronomic analysis must engage directly with the complex social contexts in which farmers operate.

KEYWORDS

climate-smart agriculture, India, political ecology, risk, system of rice intensification

1 | INTRODUCTION

Over the past decade, international development organisations have pointedly argued that supporting smallholder agriculture is a critical means to address food security and rural poverty. Although prescriptions vary, such accounts commonly invoke the need for new methods to sustainably intensify production in the context of growing input costs, volatile output prices, the degradation of land and water resources, and the manifestation of climatic extremes (United Nations Conference on Trade and Development, 2013; World Bank, 2007). These concerns are reflected in

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the current enthusiasm for "climate-smart agriculture," which promotes the identification and diffusion of agricultural techniques that can simultaneously increase productivity, promote resilience, and lower greenhouse gas emissions (Food and Agriculture Organisation, 2013; World Bank, 2015; cf. Taylor, 2017). In Asia, rice often serves as a focal point for these governmental initiatives because it is the predominant consumption staple while serving as a principal cash crop for smallholder agriculture. Many observers therefore continue to echo the concerns of Gurdev Khush who claimed that sustainably increasing annual rice production remains the defining development question facing the continent (Khush, 2004).

In this context, a relatively new and heterodox approach to rice cultivation has attracted growing attention over the past two decades. Originally systematised in Madagascar in the 1980s, the system of rice intensification (SRI) has been spread through the determined yet dispersed efforts of a committed group of agronomists, non-governmental organisations, and state agencies. In contrast to the dominant institutional emphasis on developing new high-yielding varieties through specialised breeding programmes or genetic modification, SRI is predicated upon the idea that productivity can be enhanced more effectively through a transformation of cultivation practices. To this end, SRI proposes a tightly sequenced approach to rice cultivation that—collectively—breaks from standard practices. Key facets include the individual transplanting of very young seedlings, ensuring a deliberately wide spacing between individual plants, and using alternate periods of wetting and drying in which water is added to the field only at specific moments of the growing cycle. Advocates claim that the cumulative result of this SRI method is a synergy of improved soil health, better root systems, and stronger and more bountiful rice plants that leads to substantially greater yields per hectare despite using less seeds and water (Stoop, Uphoff, & Kassam, 2002). On this basis, a number of state-level governments and non-governmental organisations within India and other countries have taken an active role in promoting SRI as a sustainable means to combine yield gains with decreased water usage (Glover, 2011a).

Although there has been considerable discussion among agronomists over the relative virtues of SRI as a method of rice cultivation, these debates often remain focused on comparing yield differentials between SRI and existing techniques (Berkhout, Glover, & Kuyvenhoven, 2015; Glover, 2011b; Sumberg, Andersson, Giller, & Thompson, 2013). Although some studies have begun to assess a broader array of social and environmental outcomes for SRI production, this research remains in its infancy (Gathorne-Hardy, Reddy, Venkatanarayana, & Harriss-White, 2016; Takahashi & Barrett, 2014; Varma, 2017). Missing from such debates, we argue, is a widening of the analytical lens to address how the adoption of SRI occurs within agrarian environments characterised by notable inequalities of resource access and in which different categories of farmers face uneven exposure to the risks involved in using new cultivation methods.

The present paper seeks to contribute to this task by applying a political ecology framework to systematically explicate how differentiated access to labour, water, and extension networks shapes the opportunities, challenges, and risks that farmers face using SRI. Given that SRI is predicated upon a tightly ordered sequence of cultivation tasks, it requires that farmers mobilise inputs including labour, water, tools, and knowledge according to a more exacting and precise timeline. The ability of farmers to do so, however, is strongly shaped by the social contexts in which they operate including the relative degree of social power that they hold. Put simply, not all farmers are equally positioned to confidently exercise timely command over key inputs. Rather, access to inputs is typically conditioned by prevailing social hierarchies structured along lines of class, caste, and gender. These factors, we argue, strongly influence farmer experiences with SRI including the relative opportunities and risks they face. As a result, they shape the trends towards adoption and disadoption of the method.

We illustrate these points through an empirical study of SRI in a semiarid region of Telangana, southern India. Our fieldwork focused upon an SRI diffusion programme financed by the state government and undertaken by subcontracted non-governmental organisations (NGOs) between 2010 and 2014. By the time of our fieldwork in 2016, farmers in the study area had largely disadopted SRI despite an almost universal accomplishment of higher yields. Through a series of interviews with farmers, agricultural labourers, and extension officers, we found that the reasons for disadoption were diverse and were driven not by yield concerns but rather by a complex range of calculations centred upon their relative access to water, labour, networks, and other inputs aligned with the demands

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of SRI production. The study indicates that the degree to which SRI may be a useful method for smallholder farmers in drought-prone regions is not simply a question of whether it delivers better yields or conserves water at the level of the field. Rather, the possibilities and limitations to SRI as a means of sustainably and equitably intensifying rice production can only be adequately conceptualised within a wider analysis of the social dynamics that distribute opportunities and risks across the agrarian environment.

2 | THE SYSTEM OF RICE INTENSIFICATION: THEORY, PRACTICE, AND DEBATE

As a method for cultivating paddy, SRI is founded upon a closely sequenced set of practices that—when combined—deviate from standard methods in several key ways. Although SRI prescriptions vary according to location and the specific implementing agency, at a basic level, five key elements define a common nucleus across the south Indian context. First, seedlings are grown in a dedicated nursery composed of a raised bed of compost and soil, typically in the middle of a field that can be flooded. Second, the fields are prepared through levelling to ensure equal water distribution and the application of organic material to improve fertility. They are then marked out in an ordered grid to guide planting according to a fixed spacing between plants of 25 cm. This represents a considerably wider distance than standard cultivation. Third, once the seedlings have reached between 9 and 14 days, they are transplanted into the main field following the marked grid, with one seedling per intersection. This early transplanting represents an important break with standard practice, wherein farmers typically transplant a cluster of three seedlings of at least 28–40 days of growth. Using young seedlings, the transplanting under SRI requires extra care to avoid damaging the young plant. In some cases, this includes ensuring that the seedling's roots are not bent upwards but form an "L" shape. Fourth, once transplanted, a carefully scheduled programme of irrigation is undertaken in which the field is not kept flooded. Rather, a moderate amount of water is introduced and then allowed to dry to the point at which only puddles remain and cracks appear in the soil. This altered water usage strategy is perhaps the most fundamental break from established best practices in south India, wherein continual flooding—that is, maintaining around 2 inch of standing water—is practiced owing to its suppression of weeds and its role in nutrient provision (Grist, 1986). Finally, a series of three weedings is undertaken in the weeks following transplanting, a process that requires a specialised mechanical roto-weeder that aerates the soil, deposits the weeds back into the field to act as organic matter, and lightly prunes plant roots to encourage growth.[1]

For proponents, these practices cumulatively result in the growth of larger and more robust plants that produce more grain bearing panicles resulting in higher overall yields per acre despite greatly reduced water usage. Although there is a continued debate about the agronomic underpinnings of SRI, four key principles are argued to stand behind SRI's potential benefits. First, early transplanted seedlings allow for the rapid and healthier establishment of the plant's roots. Second, reduced plant density by planting individual seedlings at wide spaces reduces competition and allows for stronger root structure to develop that enables larger, higher-yielding crops to flourish. Third, well-aerated soils enhanced with organic matter improve nutrient cycling and promote vigorous root development. Fourth, closely controlled water management through alternate periods of wetting and drying facilitates improved biotic soil conditions for root growth. Notably, proponents of SRI claim that the widespread practice of continual flooding in paddy fields fosters oxygen-depleted soil conditions that compromises microbial activity leading to inefficient root development and plant growth (Anas, Rupela, Thiyagarajan, & Uphoff, 2011; Barison & Uphoff, 2011; Thakur, Uphoff, & Stoop, 2016).

For advocates, it is the synergistic interplay of better soil health, stronger root formation and larger, more robust plants that underpins SRI's augmented yield potential (Stoop et al., 2002; Thakur et al., 2016). Greater yields, moreover, are argued to occur alongside a wider suite of benefits including reduced water usage and decreased external

[1]Descriptions of SRI weeders—their design and functions—can be found at http://sri.ciifad.cornell.edu/countries/india/extmats/SRIWeederManual06.pdf (accessed June 23, 2017).

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input requirements (see Kassam, Stoop, & Uphoff, 2011, for an overview). At a farm level, this win–win combination of reduced costs and greater yields is argued to translate into productivity gains and increased farmer incomes. At a social level, reduced aggregate water demands alongside a reduction in methane emissions has led proponents to claim that SRI is a more sustainable form of production that promotes greater resilience to climatic change (Kassam & Brammer, 2013; Styger & Uphoff, 2016). This would make it—in principle—an ideal climate-smart agriculture technique, on account of increased productivity, augmented climate resilience, and lowered emissions (FAO, 2013).

If the promises of SRI hold true, the method offers a means of raising productivity while conserving water resources without recourse to biotechnological solutions such as improved plant breeds or synthetic inputs. These potential benefits are amplified, advocates claim, by the way in which SRI provides a simple, low-cost, and rapidly generalisable rural development programme that can be rolled out across the Asian context. Once established, it is envisaged to spread organically from farmer to farmer as a means to improve productivity and incomes (Stoop, Adam, & Kassam, 2009). It is precisely this potential synthesis of livelihood enhancement, agricultural intensification, and climate change adaptation wrapped in a relatively simple package of altered farming practices that has made SRI increasingly appealing to policymakers and NGOs across India.

Perhaps unsurprisingly, however, an approach that questions long-standing cultivation practices—including the "best practices" promoted by leading agricultural research institutions—has attracted stringent and often acrimonious counter-critique from established agronomists (Dobermann, 2004; Sheehy, Sinclair, & Cassman, 2005; Sinclair & Cassman, 2004). Since the early 2000s, there has been a vigorous series of claims and counterclaims within agronomic circles over the relative yields attainable by SRI methods in relation to conventional best practices. For a number of agricultural scientists, the yield claims made on behalf of SRI are not independently verifiable nor can they easily be recreated in formal field trials (McDonald, Hobbs, & Riha, 2008). Some have even cast doubt on whether certain claims made on behalf of SRI are physiologically possible given accepted yield ceilings for rice production (Dobermann, 2004). SRI advocates have responded formally by citing a growing number of studies indicating yield gains and, more informally, that the escalating spread of SRI techniques among smallholder rice farmers speaks for itself (Kassam & Brammer, 2013; Stoop et al., 2009; Thakur et al., 2016; Uphoff, Kassam, & Stoop, 2008).

Although the debate over yields is important, we do not engage directly in those discussions (see Berkhout et al., 2015, for an important review). Rather, our purpose is to widen the scope of the debate by removing SRI from an overly agronomic approach. Instead, we situate it within a wider political ecology of agricultural production that focuses upon how SRI is adopted and used among farmers who have markedly different access to inputs, who are integrated in distinct ways into local social structures, and face distinct risks within the production process. In short, rather than asking the agronomic question "does SRI work?" in terms of yields or water conservation, we address the more nuanced question of who SRI might work for. Specifically, through our research in south India, we interrogate the social contexts that shape which types of farmers are able to successfully utilise this method and what barriers or risks exist that prohibit effective SRI adoption or lead to its disadoption.

These crucial issues have not been well acknowledged within the SRI literature.[2] In their pursuit of recognition among policymakers and international institutions, SRI advocates tend to mirror the technocratic approach of conventional agronomy. The latter is predicated upon the projection of scientifically proven and universally valid "solutions" to agricultural or development challenges that can be realised through a relatively simple substitution of seeds, inputs or, in the SRI case, cultivation practices (Mosse, 2005). Pivotally, in order to highlight the impact of field-level changes, such debates typically abstract away the variable social contexts that farmers face. By flattening the social terrain, agronomists seek to evaluate the relative virtues of one production technique against another in either ideal-type conditions or without significant reference to the social divisions between agricultural producers in a given

[2]In addition to the papers noted above, important exceptions include Namara, Weligamage, and Barker's report on Sri Lanka (2003); Moser and Barrett's (2006) work in Madagascar; Resurreccion et al.'s gender analysis in Cambodia (2008); and Ly, Stoumann Jensen, Brech Bruun, Rutz, and de Neergaard's (2012) account of labour dynamics and the social constraints on SRI adaptation also in Cambodia. Senthilkumar, Bindraban, Thiyagarajan, de Ridder, and Giller (2008) and Takahashi (2013) both provide an analysis of risks within SRI, although neither addresses the key point raised here concerning how risks are unevenly differentiated between social groups.

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region. On this basis, SRI is commonly presented as a plug-and-play set of technical practices that can be parachuted into diverse agrarian settings in order to create predictable results in terms of increased yields (Sumberg et al., 2013).

Agrarian environments in South Asia, however, tend to be anything but ideal. This is because agricultural production is invariably a social undertaking in which cultivation decisions about what to plant and how to grow it are shaped by a complex interaction of agroecological drivers and rural social relations (Agrawal & Sivaramakrishnan, 2000; Zimmerer & Bassett, 2003). In particular, cultivation is typically undertaken in social contexts in which access to key productive inputs—including land, labour, water, credit, and knowledge—is constrained, unequal, and subject to complex social hierarchies. To gain access to necessary inputs such as land, labour, water, credit, and information, farmers must continuously foster a variety of social relationships with neighbours, landlords, merchants, labourers, government officers, moneylenders, banks, and other social agents. These social relationships are regularly stratified along the lines of class, gender, and caste differentials in which social actors have differing abilities to shape the terms under which they interact. As political ecologists stress, such power relations strongly configure the distribution of opportunities and risks inherent to agricultural production (Bernstein, 2010; Mosse, 2010; Taylor, 2013a).

Placed in this context, the abstract farmer that typically populates agronomic discourse is an awkward placeholder for a heterogeneous set of cultivators who have markedly different access to inputs, who are integrated in distinct ways into local social structures, and who face distinct risks within the production process according to the quality and quantity of assets they hold and their social standing within a community. Farmers who exercise strong control over land tenure, irrigation facilities, institutional credit, and agricultural labourers, for example, have an entirely distinct relationship to the opportunities and risks involved in adopting new cultivation techniques than those who have tenuous command over those inputs and who must frequently enter into lopsided social relationships to gain access. At the same time, entry into networks such as agricultural extension practices that facilitate the transfer of knowledge and materials are often heavily conditioned by sociocultural relationships stratified by gender, class, and caste. This means that cultivation choices and agricultural practices are invariably embedded in an uneven and evolving social context through which inputs are sourced; labour, mobilised; and credit and information, accrued. As a result, farmers do not select between cultivation techniques simply on the basis of prospective yields or income maximisation on an individual level. They also maintain keen consideration of the social determinants of agricultural practices including how they will access the necessary inputs and the relative nature and size of the risks involved across cultivation options.[3]

3 | TOWARDS A POLITICAL ECOLOGY OF SRI

The consideration of how social relations facilitate or limit access to key inputs is particularly important for understanding the conditions under which SRI might be adopted, and the relative levels of success that differently positioned farmers may experience with the method. As noted above, SRI is predicated upon a precise choreography of production in which cultivation processes must be carefully timed and sequenced for best results. As a result, farmers who are better able to manage the social dimensions of input access are best placed to take advantage of the more exacting production method. Conversely, for farmers with less certain access, the shift to SRI can create new risks. A lack of access to labour at transplanting time, for example, can lead to delays in the timing of key tasks whereas uncertain access to water can make the practice of alternate wetting and drying a precarious proposition. This stands in contrast to conventional paddy cultivation in which there is much more flexibility in terms of the timing of labour processes and where flooded irrigation maintains a constant reserve of water in the field (Takahashi, 2013). At the same time, the knowledge and material benefits provided through agricultural extension networks can provide information and subsidies that can help reduce risks and maximise gains with the new method. Access to such networks, however, can also be stratified according to established social hierarchies, therein consolidating the uneven experience of SRI.

[3]For a longer account of the political ecology perspective that underscores this analysis, see Taylor (2015).

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TABLE 1 Total workforce by category in area under study

	Male		Female	
Cultivators	24,708	56%	14,799	41%
Agricultural Labourers	10,494	24%	18,046	50%
Household Industry	666	2%	509	1%
Other	7,679	18%	3,090	8%

Note. Data were drawn from Directorate of Census Operations Andhra Pradesh (2014).

To illustrate these points, we break down the political ecology of SRI into three central elements—access to labour, water, and networks—and we examine each in turn through a situated analysis of SRI in the district of Mahabubnagar, Telangana state, southern India.[4] Through a series of semi-structured interviews with over 50 farmers, agricultural labourers, extension officers, agricultural scientists, and NGO staff conducted between April and June of 2016, we gathered qualitative data on why farmers had chosen to be part of a programme to propagate the SRI method, what training and support they had received, what opportunities and constraints they faced in using the method, what risks they perceived at various stages of cultivation, and what levels of success they had experienced.[5] Our fieldwork sites were chosen because they had been part of a government-funded programme operational between 2011 and 2015 called the Joint Action Initiative on SRI (JaiSRI). To promote SRI across the state, JaiSRI aimed to build a nucleus of practicing farmers in villages, who would become a bulwark of SRI practitioners and the basis for further diffusion of the method. To achieve this goal, a subcontracted NGO would be commissioned to organise a general information session in each village and then ask for volunteer farmers who wished to form a facilitation group. Those willing to try the new method would then be provided with training sessions, access to basic tools including SRI mechanical weeders and markers, and the promise of subsidies to enable SRI cultivation to begin. Additionally, the facilitating NGOs would seek to organise and/or train local labour groups in the specific techniques of SRI transplanting to ensure a ready stream of capable labourers (Department of Agriculture, 2010a, b).

The intention of such institutional support was to ensure the cultivation of 30 ha of paddy using the SRI method in the first year, an additional 40 ha by the second year, and a further 30 ha by the third year. This would cumulatively establish 100 ha of paddy farmed using SRI in each site by the end of the programme. Establishing a geographically consolidated core of SRI cultivation, the programme argued, would provide the necessary traction for the technique to gain prominence and subsequently diffuse outwards within and across villages through farmer-to-farmer contact. With a 3-year presence for the project, it was estimated that there would be a smaller risk of farmer disadoption. This had hampered previous SRI extension efforts during the previous decade that had typically been 1-year programmes (Department of Agriculture, 2010a).

Although the JaiSRI programme was operational in four districts across Telangana, we focused on its operation in three mandals in northern Mahabubnagar district.[6] This region exemplifies a semiarid region in which there are high levels of agrarian distress, including incidences of farmer suicide. This distress is in part due to shifts in the political economy of agriculture and in part the growing intensity of droughts attributable in part to climate change (Harriss-White, 2008; Reddy & Mishra, 2009; World Bank, 2008). It is in areas such as these that the purported benefits of

[4]The three specific mandals (subdistricts) in which we conducted fieldwork were Kondurgu, Daulatabad and Bomraspet. Following the administrative reshaping of districts in Telangana in late 2016, the eastern most mandal in our study (Kondurgu) now falls under the new district of Shamshabad rather than Mahabubnagar.

[5]Interviews were conducted with 43 farmers with varied landholdings ranging from two to thirty acres; members of four different agricultural labour groups; two extension officers directly involved in implementation; the director of an NGO contracted to implement the programme in one mandal; and an agricultural scientist who had advised the JaiSRI project.

[6]A *mandal* is an administrative unit in Telangana typically constituted by a main town that serves as an entity of local government over a number of small towns and villages in the surrounding region.

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SRI—both in terms of yields and water conservation—are greatly needed. As Table 1 shows, agricultural livelihoods still provide the predominant means of employment, either through direct cultivation or labour.

Forming part of a common semiarid agroecological zone, landholdings in this region are typically composed of a large number of very small landholdings of less than 2.5 acres (see Table 2). Such marginal holdings are not large enough to support a household through agriculture alone and are commonly used to produce either subsistence crops or a small marketable produce as a supplement to other livelihood strategies such as agricultural labour. Above this class of marginal households, the bulk of operated land is held by small and semi-medium farmers (2.5–10 acres), who together account for just under 60% of total land in the three studied mandals. These classes of smallholder farmers typically grow some food as a subsistence support while marketing the majority of their produce. Most of these smallholders belong to the caste category of other backward castes (OBCs) or, less commonly, scheduled castes or scheduled tribes. At the higher end of the class spectrum, a small number of large landholdings exist, particularly among farmers from the elevated Reddy caste, with medium and large farmers (i.e., holdings of 10 or more acres of land) constituting less than 3% of the total cultivators, yet accounting for 16% of total land.

In terms of caste, the data collected in the 2011 Census across the three mandals that our research focused on show that the scheduled caste and scheduled tribe population ranged from one quarter to 40% of the three mandals that our research focused upon. These groups were less likely to list direct cultivation as their primary livelihood as compared with the general population (see Table 3), with a higher percentage of agricultural labourers among both men and women. Equally, regardless of caste, women were far more strongly represented in the ranks of agricultural labourers.

The farmers we interviewed were representative of those involved in the JaiSRI programme, which did not precisely mirror the broader rural population in either class, caste, or gender terms. As discussed below, the JaiSRI programme tended to focus on small- and medium-size male landowners, predominantly drawn from OBC castes, and these formed the bulk of our interviews (see Table 4). Although medium and large farmers were also well represented in the programme, few marginal farmers and very few female cultivators were included.

Farmers involved in the JaiSRI programme commonly grew rice on around a third of their total lands during the summer season and—where borewell irrigation existed—also during the winter. Other crops include groundnut, pulses, sorghum, and vegetables including corn, onions, tomato, and chillies. Cotton is a significant cash crop grown in the summer season and a recent trend has seen an expansion of contract farming for hybrid rice seeds, a process that uses a cultivation method not dissimilar to SRI. For irrigation, privately owned borewells have become the predominant means of sourcing water for cultivation across all farmer classes. Some villages retain various forms of communal tank irrigation, with tanks recharging in the rainy season before being used up over the rest of the year. However, following long-standing trends in the region, many such systems have fallen into disuse as farmers have increasingly relied on borewells that are being dug ever more deeply (Pingle, 2011; Taylor, 2013b). Although rainfall typically ranges from 500 to 800 mm annually, concentrated within the summer monsoon months, at the time of research, the region had suffered significant drought conditions over the previous 3 years and most bodies of minor irrigation were without water and a significant number of borewells were failing.

As we began our research, the JaiSRI programme in this region had been completed the previous year. No subsequent follow-up programme was immediately planned at a governmental level, although various NGOs still

TABLE 2 Number and area of landholding by size group

Type of holding (acres)	Total number of holdings	Percent of total holdings	Percent of land held
Marginal (0–2.5)	29,000	60.7	25.6
Small (2.5–5)	11,964	25.1	31.7
Semi-medium (5–10)	5,377	11.3	26.8
Medium (10–20)	1,316	2.7	13.6
Large (over 25)	88	0.2	2.3

Note. Figures were compiled from 2011 Indian Census data for the three mandals studied. These categories correspond those used in the Indian census.

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TABLE 3 Scheduled caste/scheduled tribe workforce by category

	Male		Female	
Cultivators	7,887	57%	4,687	39%
Agricultural Labourers	4,212	31%	6,812	55%
Household Industry	95	1%	82	1%
Other	1,598	12%	872	7%

Note. Data were drawn from Directorate of Census Operations Andhra Pradesh (2014).

TABLE 4 Landholdings of interviewed farmers

Category	Landholding size (acres)	Number of farmers interviewed
Marginal	0 to 2.5	5
Small	2.5 to 5	9
Semi-medium	5 to 10	17
Medium	10 to 25	7
Large	Over 25	2

promoted SRI as part of their general operations. Our research indicated that the programme struggled to achieve lasting results. Indeed, during the rabi (winter) season of 2016, the authors failed to find a single farmer cultivating rice using the SRI method despite the significant outreach effort over the previous half decade and the paper presence of many SRI farmers on the registers of NGOs. The vast majority of farmers we spoke to had given up using the practice, although their reasons for disadoption were varied. To be clear, such a finding does not discredit SRI as a potentially valuable set of practices for smallholder rice cultivation. Within our fieldwork, farmers across villages almost universally reported higher yields using SRI methods. Although variable, most reported yield gains of between 10% and 25% in comparison with standard production. Although it was not possible to independently verify such yields, it is an outcome that tallies with monitored field trials in the region (Adusumilli & Laxmi, 2011; Duttarganvi et al., 2016; Jayapalreddy & Shenoy, 2013).

By increasing yields, SRI could be regarded as a successful tool of agricultural intensification. This outcome, however, had ensured neither its persistence as an agricultural method nor its generalisation across the region. The high levels of disadoption we observed were therefore not first and foremost correlated to the question of yields but to a wider set of socioecological factors that created a sense of heightened risks and responsibility for cultivators that outweighed yield concerns. Two points are expressly important. First, these risks were constituted not at a field level but through a set of broader social processes governing access to key inputs. Second, yet relatedly, such risks were not experienced equally across farmers. Rather, by impacting how farmers accessed inputs and practiced agriculture, the class, caste, and gendered positions of farmers shaped their experience with SRI. To illustrate these key points, we focus sequentially on how access to labour, water, and networks shaped farmer experiences.[7]

[7]Access to land—including the diversity of tenure arrangements ranging from direct ownership, common property arrangements, fixed-rent tenancy, and various permutations of sharecropping—is an important influence upon the calculations about what direct producers cultivate and how they do so (Vijay & Sreenivasulu, 2013). Tenant relationships, for example, may impact upon the relative power to decide on land use decisions, the burden of input costs, which parties bear the inevitable risks of production, and the distribution of potential gains. A common sharecropping agreement in which the landlord pays half of input costs yet takes half the resultant yield, for example, dramatically reorientates the producer's perspective on a cultivation practice such as SRI, in which reduced input costs may form a significant part of the attraction. On this basis, discussions of SRI at a general level need to be more attuned to considering forms of land tenure and their influence over cultivation practices. That said, within the villages of Mahabubnagar that we studied, the prevalence of direct land ownership with relatively few instances of land rental meant that different forms of tenure were not a significant factor for this specific study.

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3.1 | Access to labour

The use of labour within SRI is a contested topic and there are ongoing debates as to whether the approach requires more or less labour than standard cultivation practices (Ches & Yamaji, 2016; Gathorne-Hardy et al., 2016; Takahashi & Barrett, 2014). For our purposes, the more important question is not whether SRI requires more or less labour, but the ways in which it shifts the nature and timing of labour processes within rice cultivation. Three elements are important. First, SRI involves a considerably more involved management function on behalf of the farmer. The latter must closely monitor the cultivation process given the precise timing and performance of key tasks. Second, SRI shifts the labour dynamics of transplanting. The transplanting of seedlings within SRI is labour intensive, time sensitive, and requires a relatively more diligent form of work. This diligence is related to the delicate nature of the young seedlings used, the required accuracy of plant spacing, and the specific way seedlings must be planted to ensure proper root development. As noted in our interviews with labourers, SRI transplanting requires an attentiveness to labour that is typically beyond the demands of traditional transplanting. Third, rather than using hired female labour groups to manually undertake weeding as in conventional cultivation practices, weeding within SRI is transformed owing to the required usage of a specialised weeder. This piece of machinery must be used according to a set posttransplanting schedule that seeks to compensate for the lack of weed suppression that would normally occur through flooded cultivation. Not only does this transform weeding from being a labour intensive activity to a mechanised task, it also shifts the gendered division of labour. Tasks involving the use of machinery are typically designated as male labour. Therefore, under SRI, weeding moves from being seen as a female to a male job.

These unique characteristics of the labour process within SRI places a higher premium on labour control than under standard cultivation. They require the farmer to mobilise labour at key points in the cultivation cycle and then monitor its diligent application to tasks that are commonly regarded as comprising significant drudgery. The ability of cultivators to effectively deploy the SRI method is therein influenced by their relative access to suitable labour in both quality and quantity. To address this challenge, different classes of households use different forms of labour recruitment depending on the task at hand. Larger-scale farmers typically use primarily hired labour for all tasks, including transplanting and weeding. Those with smaller holdings tend to use hired labour for transplanting and a mix of household and hired labour for other tasks. As a result, transplanting is the key moment at which farmers of all types seek to contact labourers. Given the time constraints of SRI—wherein seedlings are best transplanted at around 12–15 days of age—there is a tendency for the expansion of SRI to create bottlenecks wherein multiple farmers require labour for transplanting at a specific moment and therein are forced to compete with other farmers to attract labourers.

In the case of Mahabubnagar, this shift in labour demand occurred in the context of a rural labour market undergoing significant transformation. Historically, Mahabubnagar was known for the widespread presence of rural labour forces mobilised and controlled through a combination of caste-based patronage relationships and debt bondage (Picherit, 2009, 2016). According to key respondents in the research areas, however, such relationships had become far less prevalent as a means of mobilising and controlling labour since 2008. This was in part because former caste elites had increasingly moved out of agriculture whereas landless labourers were circulating to urban regions for work, both in regional centres such as Shadnagar and further afield in large cities including Hyderabad, Bangalore, and Mumbai. At the same time, the introduction of a rural employment programme through the National Rural Employment Guarantee Act (NREGA) was noted by a number of interviewees as further shifting the bargaining dynamics between labourers and employers. Although controversial in its design and implementation, the latter theoretically guarantees rural households labour for 100 days as a form of subsistence guarantee designed to alleviate distress migration (see Pattenden, 2017, for an in-depth study in neighbouring districts of Karnataka). Over the past half decade, these changing dynamics of rural labour have cumulatively underscored a steady rise in wage rates for agricultural labourers—albeit from very low rates—and a deepening sense of a "labour shortage" among farmers.

The potential shortage of labour with suitable skills and desired price levels was acknowledged as a risk within the JaiSRI programme. The latter specified that a "SRI labour economy" must be established with clearly set wage

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rates for SRI work among appropriately trained labourers (Department of Agriculture, 2010a). Facilitating NGOs were therein tasked not only with training farmers in the SRI method but also to organise labour groups for SRI transplanting and to establish standard wage rates for transplanting tasks. These agricultural labour groups are a common feature of the agrarian landscape across India. They tend to be almost exclusively female and are formed from landless labourers or smallholder household members, typically with one woman acting as a lead organiser. Frequently, they take shape around the institutional structure of self-help groups that had been formed throughout the region over the previous two decades as a means of connecting rural women with state distributional structures and microfinance initiatives (Rao, 2008; Taylor, 2011).

Although JaiSRI mandated NGO facilitators to seek to confirm standard rates for SRI transplanting explicitly to avoid escalating wage costs, these efforts were only partially successful and most farmers could only secure access to labour through direct negotiations with labour groups. It is notable, that many cultivators highlighted the need to actively secure labour at the specific times needed through either paying a premium price or by seeking to preemptively book labour groups with significant advance notice. Not all farmers are equal in their ability to contract labourers, particularly in conditions of relative labour shortage and rising agricultural labour rates. Many noted that paying a premium—including both higher wages and on-site palm liquor (toddy) was necessary to secure labour at needed times leading some to complain that they had little option but to wait while more affluent farmers contracted available labour at inflated rates.

For their part, some labour group members suggested that they contracted with farmers simply on a first-come, first-served basis. Even within the same labour groups, however, other respondents suggested that they in fact prioritised farmers willing to pay more money or who had enough land to offer a more consistent period of work. Notably, farmers of all size landholdings noted increasing wage rates and a tendency towards competitive bidding to secure labour. This bidding did not occur on a level terrain, however. A number of agricultural labourers suggested that working for relatively larger landowners was preferable for two reasons. First, the increased scale of the land implied a more constant stream of work and remuneration as compared with working on smaller plots of land. With labour groups normally comprising around 10–15 female labourers, working on a larger plot of land also secured simultaneous employment for the full group. Second, farmers with smaller holdings tended to more closely manage the labour process, thereby giving less opportunity for self-direction and potentially slackening the pace of work. Counter-intuitively, labourers preferred working for larger landowners where their labour might be more self-directed rather than under constant scrutiny. On this basis, in a context of labour shortages and rising wage rates for rural labourers, larger landholders retained an advantage in securing timely labour for transplanting notwithstanding the dissipation of previous patronage relations.

Two specific examples illustrate further elements of this process. First, one SRI farmer from a more affluent village noted how other farmers sometimes struggle to find labourers, but he faced no such problem. This confidence about securing labour at transplantation time was reflected in his dual status as a larger landowner and being an important input dealer upon whom other households depended for seeds, chemicals, and sometimes advice in using such inputs. In addition to being able to provide a longer and more consistent opportunity for labour groups owing to his substantial land holdings, this farmer had significant social status owing to his commercial role. Input dealers typically provide seeds and fertiliser to cultivators on credit at the beginning of a season, creating patronage relations with small and marginal farmers, including household members that form labour groups. As a result, the farmer was able to display strong confidence in securing labourers precisely when he needed them. He did, however, note that although labour groups would likely prioritise him as an employer, prices had nonetheless risen and that he was expected to provide palm liquor as an added incentive. Conversely, a marginal farmer from a more remote village noted how, at peak times during the agricultural season, offering up to double the typical rate (Rs200) could still be insufficient to secure the needed labour in time. As a result of this inability to find sufficient labourers, the transplantation of seedlings was delayed past the recommended 15 days until they were 25–30 days old.

These two experiences stood at either pole of the risks involved in securing labour for transplanting. It is notable that only a quarter of surveyed farmers with four or more acres of irrigated land reported transplanting seedlings

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older than 15 days, suggesting they had relatively little trouble accessing timely labour. In contrast, among farmers owning three or less acres of irrigated land, delayed transplanting was preponderant with 70% of farmers planting seedlings older than 15 days.[8] The impacts of these delays upon yields are unclear, but it is worth highlighting that early transplanting is regarded as a pivotal feature behind the potential success of the SRI method owing to the way that young seedlings form vigorous root systems as compared with older plants.

Following transplanting, the other major labour process within SRI is weeding. As has been noted elsewhere in the literature, SRI practices can effect an important shift in the gendered division of labour within the agricultural cycle (Resurreccion, Sajor, & Sophea, 2008). This is because manual labouring tasks involving heavy drudgery—particularly transplanting and weeding—are culturally designated as female work and are typically paid far less. The SRI method, however, requires the use of a mechanical weeder that is designed to simultaneously remove weeds and aerate the soil. For the majority of farmers surveyed, this meant that weeding transitioned from being female to male work, in part owing to customs associated with the use of technology and in part because of the difficulty of pushing the weeder through black clay soil. Some female labourers noted that they still had a role in SRI weeding, yet this was more limited: following the male weeder to collect materials displaced by the machine and to remove weeds close to the plants that evaded the reach of the mechanical weeder. This generally involved two women, instead of a typical hired labour group of 8–10 and—for small-scale farmers—was normally taken on by household members rather than paid labourers.

Most medium- and larger-scale farmers hired male labourers to undertake weeding, a transaction that they complained was costly. As "male" work involving a machine, such labourers charged more than double what female weeders would earn. At the same time, the difficulty of weeding with the rotary weeder meant that hired workers were often argued to do a poor job, requiring a stronger supervisory role on the part of the landowner. Conversely, a significant majority of marginal and small farmers who tended to take on weeding duties themselves complained of the difficulties of weeding, particularly those whose land was comprised of black soil rather than red or sandy chalka soils. Some suggested that this was the most important reason for disadopting the technique. For such farmers, SRI was presented as a poor option owing to the increased drudgery of the labour involved. Importantly, this drudgery still existed within conventional paddy cultivation but was habitually transferred onto women who were hired to weed. In this respect, a significant impediment to the generalisation of SRI was the manner in which it upset the established gendered division of labour in which drudgery tasks were displaced onto the female labour force.

3.2 | Access to water

Paddy production using SRI methods is widely celebrated for requiring a smaller overall quantity of water for cultivation (Satyanarayana, Thiyagarajan, & Uphoff, 2007). Without doubt, given current and anticipated levels of water scarcity across South Asia, this appears to be a compelling feature of the method. Field trials within Mahabubnagar, moreover, suggest that significant water savings can be made (Jayapalreddy & Shenoy, 2013). Alongside a quantitative reduction in the overall amount of water required, however, SRI cultivation also creates new management demands regarding the practice and timing of irrigation. Unlike flooded rice production, adopting SRI uses an alternate wetting and drying method that requires a precise choreography of when water should be introduced to fields in order to allow the field to dry before water is reapplied. As noted above, this is a central pillar of the method as it is designed to better aerate the soil, leading to more robust plant growth. Compared with standard cultivation, however, SRI farmers need to exercise a more exacting control over flows of water as a prerequisite for success. The ability to flood the field at will through controlled irrigation is central to successful alternate wetting and drying. Outside of access to canal-sourced irrigation or reliable tanks, having a functioning borewell to provide water "on demand" is therefore a prerequisite for considering the SRI method. Similarly, the ability to drain excess water from the field in monsoon periods so as to avoid inadvertent flooding is also important.

[8]Similarly, farmers with larger land holdings were significantly more inclined to follow the recommended practice of planting a single seedling per hill, whereas smaller producers were more likely to follow the risk adverse yet less beneficial method of planting two.

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For many farmers, these dimensions of water usage within SRI present an opportunity in terms of reducing water use but also a management challenge and a higher degree of risk. For those with uncertain access to water, allowing the field to dry out at the surface level requires them to make a calculated risk on whether water will indeed be available for the next watering. This is not simply a technical question of aggregate water availability but also a social question. In agrarian environments, control over water is rarely constituted at the level of the individual farmer but rather depends on a complex and often hierarchical sociotechnical infrastructure that collects and distributes water to fields (Mosse, 2003; Baviskar, 2007). Whether sourced through canal, tank, or groundwater irrigation, control over water is typically characterised by inequities of access, irregular fluctuations of supply, and uncertainties over both the social and technical conditions for future access. The more complex water management demands of SRI are therefore inextricable from the political ecology of water and its core questions of access, reliability, and risks. As a consequence, while the prospect of reducing aggregate water use is undoubtedly an attractive proposition, we must pay close attention to the how SRI's complex water management demands may create new risks in conditions of inequitable or uncertain access to irrigation.

Within the researched areas of Mahabubnagar, irrigation is primarily by individual borewells that are occasionally supplemented in some villages by minor tank irrigation. The particular rock formations that underlay this part of the Deccan plateau allow for the presence of small pockets of water that collect in cracks and fissures. These underground aquifers are highly uneven in both their geographic spread and are typically shallow in their depth. When accessed via drilled borewells, they can often be depleted over the course of the season, needing to be refreshed periodically through rain. Those regions that have significant bodies of surface water nearby can expect better replenishment rates. One village, for instance, had a stronger prevalence of SRI in part because the presence of a large lake—one of the few bodies of standing water to survive the drought of 2016—aided groundwater replenishment and gave farmers a stronger degree of certainty in water supply. Alongside these physical determinants of water availability, however, access to groundwater, is socially mediated in three key ways. First, it requires farmers to invest in drilling borewells on their land with no guarantee that an aquifer will be struck. Given the costs involved, farmers typically borrowed money from either formal or informal sources for well drilling, therein taking on significant financial risk. Second, borewell irrigation is reliant upon the provision of electricity to drive the pump. Although the state government publicly guarantees 8 hours of electricity provision per day to farmers, actual supply is intermittent and patchy. Third, the amount and duration of water accessible from underground aquifers is shaped by the presence of borewells on neighbouring farms that may tap into the same aquifer. Farmers with deeper borewells could literally suck the water away from neighbours and onto their own farms.

Under these conditions, in the decade preceding JaiSRI, farmers had followed a form of debt-driven well drilling that saw an abundance of borewells sunk across the region with farmers competing to drill deeper and secure access to aquifers (Kumar, Sivamohan, Niranjan, & Bassi, 2011; Taylor, 2013b). One farmer in the village of Bomraspet had sunk a total of 25 borewells across 4 acres of irrigated land, with only two of those wells functioning at the time of our fieldwork. Given the significant costs of drilling, this indicates the desperation to which farmers are prepared to ensure their access to water. In some regions of the state, groundwater user associations have been formed to try and mitigate the tendency of a "race to the bottom" of the aquifer (Reddy, Reddy, & Soussan, 2010). None of these were present in the villages surveyed. As a result, with increasing numbers of farmers drilling into a finite number of aquifers, borewells became increasingly unreliable, particularly in years of intermittent rainfall or drought. For such farmers, the danger of using SRI was that their borewells would become unreliable—either through overuse or electricity disruption—at the moment of the alternate wetting and drying cycle in which there was no water in the field. This could lead to a diminished or ruined crop.

In response to these perceived risks, more than half of the farmers surveyed practiced a modified form of SRI that involved maintaining a steady amount of water—typically 1 inch—in the field throughout the growing phase. The idea was that such water would provide a buffer against short- to medium-term disruptions in supply and help suppress weeds. Notably, however, this practice contradicts one of SRI's core principles that allowing the field to dry until cracks appear allows for greater aeration of the soil. Given the pivotal role of soil aeration in SRI thinking,

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maintaining flooding is a significant deviation from established practice and raises questions as to whether the alternate method could still meaningfully be described as SRI. Nonetheless, the practice had become mainstreamed among many villages to the extent that it had been taught as standard SRI method by some of the NGOs operating in the region.

Importantly, there is a notable class dimension to groundwater usage that directly relates to SRI adoption and success. On one level, more affluent farmers have more secure access to credit, allowing them to borrow from formal institutions at a fraction of the cost facing those farmers who turn to moneylenders (Taylor, 2013b). On another level, landowners that have larger, contiguous plots have greater certainty over groundwater supplies because it is less likely that neighbouring farms are tapping into the same small aquifers. They therefore have stronger certainty regarding the rate of depletion of groundwater, allowing them greater confidence to implement the alternate wetting and drying practice associated with SRI. For those with borewells on small plots, in contrast, the likelihood that neighbouring farmers are accessing the same finite supplies of water are increased. Notably, in our survey, those farmers with larger landholdings were much more likely to have implemented the full alternate wetting and drying method associated with SRI, whereas those with small and marginal landholdings were almost exclusively using the adapted method to counter the risk of borewell failure. It is not possible from our survey to measure the impact of this variation in practice upon yields. On the one hand, small and marginal farmers who practiced the altered method still reported yield gains. On the other, such farmers reported notably smaller yield gains than larger farmers, although the precise impact of differing water management strategies could not be separated from the other factors we have discussed.

3.3 | Access to networks

Although SRI is often described by its advocates as a "bottom up" approach that is spread from farmer to farmer, both the literature and our fieldwork experiences suggest that the extension of SRI practices is driven primarily through a strongly institutionalised push to diffuse the technique backed by significant material resources sometimes including direct subsidies (Basu & Leeuwis, 2012; Johnson & Vijayaragavan, 2011). In practice, the generalisation of SRI frequently takes a unique combination of dedicated agronomists, NGOs, farmer networks, and state resources that collectively establish appropriate training and knowledge dissemination, the establishment of model farms, the provision of specialised equipment such as weeders, and the institutional legitimation for farmers to try a radically new form of rice cultivation. Notably, some extension programmes provide guarantees against the risks of adopting new and unfamiliar practices, with subsidies either delivered on the input side or a guaranteed price for outputs. SRI is therefore not a spontaneous bottom-up transformation but an instituted process that relies on the production of new networks to distribute the requisite knowledge and material resources. The significance of this point is that such processes are often uneven in application, both spatially and across social groups. A question arises as to whether the institutional processes through which SRI is enacted may create its own dynamics of inclusion and exclusion along lines of village, class, caste, or gender.

In the case of JaiSRI, the programme to institutionalise SRI was beset by a number of problems. As internal reports noted, the flow of funds from the Department of Agriculture to the facilitating NGOs and then to the field level was frequently delayed or disrupted. At the same time, NGO efforts were uneven across villages, with some subcontracted organisations performing their roles more ably and consistently than others (AP SRI Consortium, 2014a, 2014b). With NGOs and field-level operatives paid according to recorded successes, all involved in the programme were extremely keen to project a strong record of accomplishment, even when it appeared to contradict the situation we encountered in the villages. On the ground, it was clear that some villages and individuals benefited from closer attention of extension operatives, particularly those villages and individual farmers who had a longer history of NGO–farmer interactions.

As an example, in one relatively prosperous village located on the main road, for example, the local NGO had a long-standing relationship with numerous farmers in the village who had been established recipients of training, tools,

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and subsidies, including but not limited to SRI. Extension efforts were particularly evident in this concentrated and accessible geographic cluster, particularly with established farmers with medium to larger landholdings. Several kilometres to the south, away from the main road, however, a second village that was part of the JaiSRI programme had seen little extension activity. The weeding machines that the village had initially been given were in disrepair and farmers that persisted with SRI had resorted to hiring labourers to hand-weed the land. In this village, only a single large landowner with strong educational background continued to use the technique, whereas other farmers noted their unwillingness to continue on the lack of certainty of how to employ the method in conditions of an absence of expertise, failing tools, and recurrent water shortages. In short, the flow of extension activities through established networks seemed to be consolidating geographically uneven development.

Just as SRI training replicated established extension networks, so too did subsidies for the programme. Different types of subsidies were employed across JaiSRI as either a guarantee against risks or, more basically, an incentive to trial the method. Although some farmers received direct cash transfers as either a flat fee per acre in the first year or a contribution towards labour costs, others received a more basic incentive of seeds or fertiliser. It should be noted that the direct cash subsidies were prevalent only in the first year of the programme, prior to delays in funding from the government. Importantly, these appeared to go most commonly to larger farmers who were enrolled early in the programme. The three farmers who reported highest subsidies of Rs1,000 per acre owned a minimum of 5 acres of irrigated land, were well educated, owned higher caste, and had strong connections to previous agricultural extension initiatives. Other small- to mid-size farmers clustered in villages that had strong ties to the local NGO received Rs500 per acre. Conversely, those with lowest land holdings typically reported either undelivered cash subsidies or the provision of seeds and/or fertiliser. That subsidies were promised but not delivered was a common complaint, although one extension officer was keen to emphasise that cash subsidies were never formally guaranteed to farmers. This had little resonance with farmers, many of whom said they were still waiting for a one-time Rs500 incentive fee per acre, although they had few expectations that it would arrive.

Finally, the initial JaiSRI programme directives also specified the goal of subsidising farmers to cover increased labour costs. This aspect of the programme, however, was extremely uneven among villages and between farmers and did not seem to have been realised in more than a handful of individual cases. The initial programme guidelines left it open whether subsidies would be directed to farmers that hire labour or to the labour groups themselves. In one village, the female labour group members we interviewed argued that they had not received subsidies, whereas some male farmers noted that they had been distributed directly to them in the first year of the programme. In this respect, the subsidies for labouring activities in the first year of the programme appeared to be directed towards male farmers rather than female labourers.

Alongside the unevenness of subsidies, the specific tools needed for SRI such as the weeders and marking instruments were also distributed in an uneven manner. Some farmers were simply given tools; others were deposited with local collectives for borrowing or rental. This distribution appeared somewhat haphazard and was in part dependent on the practice of different NGOs. One NGO that was more fully embedded within the locality followed a practice of centralised sharing of tools, whereas others tended to give them directly to farmers, particularly the larger farmers, or to the village-level SRI facilitation committees. Similarly, in terms of training, some farmers were taken to see model farms and receive instruction in the district of Warangal where SRI has a longer establishment in some areas. For other farmers, little more than verbal instructions were provided with minimal follow-up. This accords to one study in Mahabubnagar that found SRI farmers had a patchy understanding of some SRI techniques (Nirmala, Vasantha, & Supriya, 2015). On a gender level, training was almost exclusively given to male farmers. Where we encountered female farmers who had previously practiced SRI, they had learned the skills in their role as day labourers and translated them into family lands.

Finally, there were some notable aspects of *gatekeeping*, a practice wherein powerful figures establish themselves as nexus points within the workings of state programmes to either promote their status or generate income (see Pattenden, 2016, for an excellent overview). In one village, the head representative for the SRI facilitation committee was a farmer who did not, and had not, practiced SRI. In another village, a large landowner and member

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of the leading Reddy caste had been selected to showcase SRI production as a *model farmer*. As with previous agricultural extension initiatives in the village, he was duly subsidised to use the SRI method on 1 acre of his irrigated land. Notably, once the subsidies had ended, the farmer quickly disadopted SRI on account of it needing too strict a control over labour in the field. The slight increases in yield he gained from the method, he felt, was not worth the added investment of his time or the risk that labourers would misapply the techniques. In terms of acting as a model farmer, he noted that only one other farmer from the village engaged the technique, and he had learned about it from a different extension programme.

4 | CONCLUSIONS

The experience of farmers with SRI in northern Mahabubnagar reveals an interesting paradox that raises important questions about how to analyse the propagation of new agricultural methods and technologies. Expressed in terms of immediate field-level outcomes, the rollout of SRI in the districts surveyed seemed to be a success. Farmers across villages almost exclusively reported higher yields and there was a generalised agreement that the method also required less water than conventional production. Together, these results—both key aims of the original extension programme—appeared to suggest that SRI could play a potentially useful role in the revitalisation of smallholder farming in the semiarid region, contributing to a more 'climate-smart' form of rice production. Paradoxically, however, such positive outcomes did not preclude the same farmers from widely disadopting the method after only a season or two of usage. Within standard agronomic analysis, this outcome appears as both counter-intuitive and irrational because farmers are expected to choose the cultivation method that best maximises production in relation to inputs. Moreover, widespread disadoption disrupted the programme expectation that successful farmer experiences with SRI would unleash a grassroots generalisation of the method as farmers would emulate their successful SRI-practicing neighbours.

In contrast, by deploying a political ecology framework, we have argued that this tenuousness of SRI despite the achievement of higher yields points to the limits of analysing SRI as purely a field-level management choice. Demonstrating whether SRI "works" or not in the manner of conventional agronomic debates is likely a misguided question. What is more important is the question of who SRI might work for, under what conditions, and why. To answer those questions requires an explicitly holistic analysis that recognises how farmers make decisions as part of a broader social context in which access to key inputs is both constrained and uneven. As our research in Mahabubnagar demonstrated, the social dynamics of class, caste, and gender make a tangible difference to how opportunities and risks are produced and distributed under SRI. These are not external or accidental factors that can be pushed to the margins of analysis. Rather, they are inherent factors within both the dissemination of SRI and its subsequent practice. In this respect, our research suggests that an analysis that puts cultivation firmly in its social context is essential for conceptualising both the possibilities and limits of SRI. If it is to contribute to a more equitable and sustainable smallholder agriculture, SRI needs to be explicitly framed within a wider understanding of rural social dynamics with specific attention to the ways in which different categories of farmers and labourers might engage the method and the attendant opportunities and risks they face. Although our research focused on access to labour, water, and extension networks, further investigation is needed to understand how unequal distributions of land, credit, and market access also shape the experience of SRI.

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ORCID

Marcus Taylor http://orcid.org/0000-0003-0944-601X

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